Additional risk analysis was conducted using more conservative assumptions with respect to Antelope Valley ridership potential. This scenario takes the ridership study estimate as the median value for through ridership despite the issues outlined above but assumes a 40% risk range around this median value. Ridership originating and terminating at the Palmdale station is estimated at only 20% higher than the Ridership Study estimate. The percentage retained at Santa Clarita is modified as described above. The result is a mean estimate of only 671 thousand net riders lost due to implementing the Palmdale alignment. Despite these conservative assumptions there is almost a 10% probability in this scenario that there will be a gain in ridership due to implementing the Antelope Valley alignment.

2.4 Conclusion

The preceding arguments indicate that the HSR ridership and revenue forecasts have a significant degree of uncertainty and are especially likely to be underestimated. They also particularly underestimate short-distance trips. As a result, it is impossible to draw a definitive conclusion as to whether the Antelope Valley route is better or worse than the Grapevine Pass route. In fact, it is likely that the Antelope Valley alignment could be the **best** route given the model specification if the increases in demand associated with short-distance trip making and induced demand were take into account.[18]

The ridership study does not provide sufficient evidence for discarding the Antelope Valley alignment. Clearly, much more detailed study is needed before a definitive selection of alternatives can be made for the different alignments in terms of demand and revenue.

[18] In a separate section of this report we investigate the implications of commuter rail service from Palmdale station which further supports the Antelope Valley ridership forecast estimates.

3. COST UNCERTAINTIES AND THEIR IMPACT ON ALIGNMENT CHOICE

The estimated difference in capital costs between alignments is $540 million. This is based on preliminary engineering studies which indicate a cost per mile of $30 million via the Grapevine route and of $25 million via Palmdale.[19] In the analysis done thus far these estimates were treated as certainties. By relaxing the assumption of certainty, it is possible to address additional issues and clarify the analysis (Exhibit H shows a summary comparison of alignment scenarios).

3.1 General Uncertainty of Engineering Estimates

All engineering estimates contain uncertainties. This is reflected in the capital cost numbers in the form of a contingency amount of 25 percent to cover upside risk[20](See Exhibit N). This is the appropriate way to reflect capital risks from the standpoint of capital budgeting, as it insures that funds are budgeted to cover potential overruns when a project is implemented. From the point of view of the overall cost benefit analysis of a project it is a reasonable, though conservative, method. It allows for the possibility of higher than expected costs, though not of lower than expected costs.

It is less appropriate for comparison between alternatives, especially where the difference in cost between alternatives is low relative to the uncertainties surrounding each alternative. In that case risk analysis, which shows the probability of higher or lower costs for each alternative independently, can show the probability of the total costs being significantly different from each other. Construction of high speed rail lines has considerable uncertainty associated with it, and so merits this approach.

3.2 Gradient issues

Construction plans for the Grapevine Pass segment of the HSR line are based on the use of 5% grades to limit the amount of expenditure necessary to cross fault lines at grade (Exhibit J). There is widespread belief in the technical community that the recommended technology will work at 5% grades, although this has not been attempted in conditions similar to those which will be found in California. Since the uncertainty cannot be resolved before the project is implemented, the 5% gradient option has been selected. If technical problems are encountered then trains will still be able to operate on the 5% gradients. However, operating modifications would then be necessary which would involve lower average speeds, which might offset the gain in time from the shorter alignment.

3.3 Tunneling

There is considerably more tunneling involved in the Grapevine alignment than the Antelope Valley alignment. Tunneling involves considerably more cost uncertainty than other forms of construction. Therefore the tunneling costs have been broken out for the purposes of risk analysis. The additional cost per mile for the Grapevine route is $5 million per mile. This is

[19] The California Intercity High Speed Rail Commission (1996), *Summary Report.* Table 8-13.
[20] The California Intercity High Speed Rail Commission (1996), *Summary Report.* Table 3-3.

taken to represent tunneling and related costs. This results in a total expected cost of $396 million for tunneling and related costs for this alignment (see Exhibit I).

3.4 Environmental Issues

Environmental impacts, as note in the Commission's summary report, are expected to be greater for the Grapevine alignment. These impacts are to be fully mitigated and the estimated costs of each alignment fully reflect these mitigation costs, which are higher for the Grapevine Pass. Because environmental mitigation costs are often much more difficult to predict than other construction costs there is a strong argument for greater uncertainty surrounding the costs of the Grapevine Pass than for the Antelope Valley. The large contingency amount for the whole project makes this insignificant from the point of view of the larger project. However, it is highly significant in comparing the alternative alignments (Exhibit I).

3.5 Risk Analysis

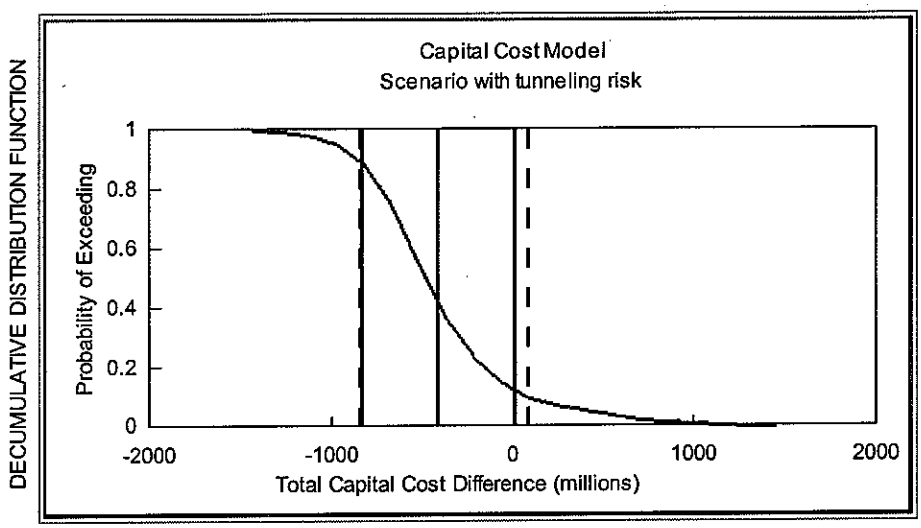
The projected costs were used as median values for risk analysis (see
Table 0-1). In order to reflect uncertainty, risk analysis utilizes estimates of a probability range. It is estimated that there is an 80% probability that the value will fall in this range. Construction costs via either alignment were treated as independently varying up to 20% in either direction. Tunneling costs were considered more risky. The high end of the probability range for this variable was estimated at 100% above expected cost. The low end of the range was treated as 10% below expected costs.

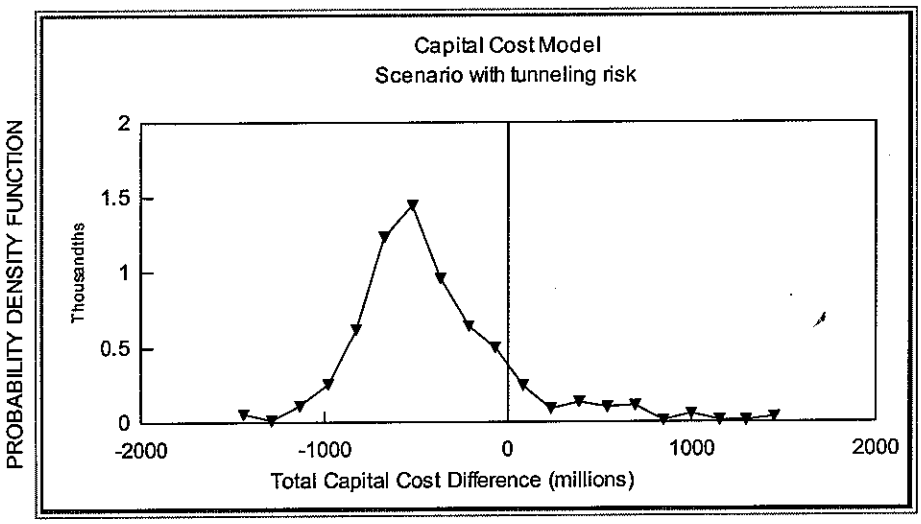
The risk analysis indicates in an estimated mean incremental cost of $419 million for the Antelope Valley alignment. This means that the expected value of the additional cost of routing via Antelope Valley, when the above risks are considered, is only $419 million. There is an almost 15% probability that the cost via Antelope Valley would in fact be less. Figure 0-1 presents the results of the risk analysis for capital costs of the alternative alignments.

Table 0-1 - Inputs for Risk Analysis of Capital Costs of Alternative Alignments

	Median	Lower 10%	Upper 10%
Grapevine Tunneling Cost (million)	$396	$356	$792
Grapevine other construction costs (million)	$2,024	$1,923	$2,530
Antelope Valley construction costs (million)	$2,960	$2,664	$3,256

Figure 0-1 Risk Analysis Results of Alternative Alignment Capital Costs





Capital Cost Model

Scenario with tunneling risk

TOTAL CAPITAL COST DIFFERENCE (MILLIONS)

Value	Probability of Exceeding Value to the Left
-1270.02	99%
-971.00	95%
-855.69	90%
-734.26	80%
-642.31	70%
-567.70	60%
-489.33	50%
-406.16	40%
-297.62	30%
-152.50	20%
77.35	10%
458.91	5%
1056.98	1%
Mean = -419.69	**Std. Dev.=422.09**

4. ECONOMIC DEVELOPMENT AND ALIGNMENT CHOICE

This section of the report investigates the potential economic development impacts associated with the Antelope Valley high speed rail alignment in California. As with most economic impact studies, the approach and results presented here were developed with full recognition of the problems associated with measuring benefits which are captured in other parts of the studies. For instance, economic impact benefits in the form of jobs and income are often just other measures for the value of new transportation captured by users of the system. That is not to say that these are not "real" benefits, they cannot just be added to user benefits.

Furthermore, economic impacts associated with a new transportation investment are in some cases transfers from one county to another or from one state to another. In this sense, the investment does not generate an incremental change in economic activity. In addition, the economic impacts associated with the building of the new transportation infrastructure are typically short term in nature.

With all of these limiting factors in mind, the proposed methodology measures the incremental impact of locating high speed rail in the Antelope Valley versus the Grapevine Pass. The methodology accounts for the amount of economic activity which is new to California rather than transfers from other regions, and it develops an explicit link between the transportation improvement (high speed rail) and new economic activity. It also provides estimates of the short run impacts associated with station development at Palmdale.

As mentioned, economic development impacts are typically reported in terms of jobs and income. These measures of impact are further broken down into direct, indirect, and induced impacts. Direct impacts are attributable to the initial investment, indirect impacts result from the spillover effects in the markets for intermediate goods and induced impacts result from the spending and re-spending of dollars earned by individuals who become employed as a result of the initial investment.

The economic impact methodology is presented in two parts. The first relates to the potential for long run incremental economic activity in California as a result of adopting the Antelope Valley alignment. This incremental activity is generated principally by individuals who choose to locate in the Antelope Valley region as a result of better access to Los Angeles, San Francisco, and intermediate points.

It is also highly likely that businesses will choose to locate in the Antelope Valley following the introduction of high speed rail. Business location decisions are complex and difficult to model because of the interaction of all the factors which influence a location decision. By isolating the analysis on the behavior of individual travelers and the ability of the community to absorb future housing and employment growth, the methodology does not over attribute economic impacts to high speed rail in Antelope Valley. In this sense, the results likely represent a minimum in terms

of new economic activity which would be generated with the addition of the Palmdale station.[21] The second part of the methodology relates to the short run employment and income impacts associated with building a station at Palmdale.

4.1 Long Run Economic Development Impacts

The economic, demographic and physical characteristics of Southern California are such that the development of high speed rail could have a measurable impact on economic growth. This becomes most likely when dynamic and fast growing communities, such as Palmdale, Santa Clarita, Lancaster, and Bakersfield, are provided with links to large metropolitan centers such as Los Angeles and San Francisco. Connecting these communities is not only positive in terms of the viability of the rail line itself but also in terms of the impact on the statewide economy (see)

.

To the extent that new transportation links improve the performance of the state economy, these improvements are more than just a one time injection of economic activity into a region. New transportation improves the efficiency with which labor and goods move throughout the economy, and they bring communities closer together. As such, the impacts are dynamic and long run.

In what follows, we describe the methodology for estimating long run economic development impacts from the Antelope Valley. This methodology is based on the potential for residential development and economic growth in Southern California. This will ultimately be supported by a mix of new industries in the local communities as well as the metropolitan centers for which access has improved.

Economic theory emphasizes the role of investment in rail in reducing transportation costs and facilitating accessibility throughout a region. The economic benefits mainly result from the reduction in travel time and the elimination of congestion—the negative externality for highway users. Firms that uses transportation in their production process also benefit greatly from the improvement to the transportation system. Lower transportation cost, for firms, is translated into lower logistics cost, therefore higher productivity gains.

As one of the main elements of total logistics costs, transportation represents one of the major points of leverage available to firms in seeking to secure productivity growth. When costs on the transportation decline, logistics managers can restructure warehousing and inventory functions accordingly, thereby obtaining greater savings than those attributable to transportation alone. This leverage occurs through various applications of goods movement.

4.1.1 Business Logistics and Network Spillovers

The cause-and-effect dynamics outlined above indicate that investment in high speed rail can be expected to create two positive economic effects -- benefits --. These are:

[21] A Commission report by Economics Research Associates ranks the Palmdale station among the top five of the twenty five proposed high speed rail stations in terms of station related industrial development. ERA estimates this development to be $164-$184 million.

Structural reductions in logistics costs -- productivity gains and corresponding cost reductions in firms that restructure their logistics function in response to a faster, more interconnected and reliable transportation modes; and

Spillovers and Externalities -- productivity gains and corresponding cost reductions in firms that accrue the spillover benefits of restructured logistics. Benefits to the firm also include *better access to the labor market.*

4.1.2 Residential Development and Economic Growth in Southern California

The principal economic mechanism by which the Antelope Valley alignment for HSR will generate economic growth for California is by improving access from points north and south to affordable land and housing which is suitable for residential development.

Land and Housing as Growth Constraints

One of the principal constraints on economic development in Southern California is the high price of housing compared to other metropolitan areas with which Southern California competes.[22] (see Exhibit L) This forces employers and population to shift to lower housing cost areas such as Arizona or Colorado. High priced housing is largely driven by the shortage of residential land in the Los Angeles area. There is relatively little land left suitable for residential development within a reasonable distance of the key employment centers in the central part of the region. The finite nature of land has an important impact on the relationship of transportation and economic growth strategy. Any strategy to increase economic growth, whether implemented by the public or private sectors, will be limited in its ultimate effects. As a particular sector grows, and the number of employees increases, these employees will add to the demand for and thus the price of housing. This will serve to displace jobs in other sectors.

Development Scenarios

If, in the extreme case, greater LA has completely exhausted its supply of residential land and there is no possibility of increasing the average density of development by increasing the number of housing units per acre, then any employment gains in one sector would result in one-for-one losses in other sectors due to limits to housing availability.

This extreme scenario is unrealistic for the following reasons. There is some potential to increase housing density in LA by further shifts to townhouses and apartments. Some employers can shift operations to locations on the periphery of the metropolitan area closer to vacant land which may be too distant for travel to the more central locations.

Many industries cannot readily shift to an "edge city" location more distant from supporting services, international air service, and other key locational factors. There may be other constraints limiting the growth of the "edge city" locations. Lifestyle preferences will limit the

[22] Economic Impact Studies by the Commission highlight this characteristic of California as one of the principal motivating factors for economic development.

shift away from single family homes. In addition, there are institutional constraints that make it difficult to increase density.

By developing an HSR link to the Antelope Valley, which is suitable for timely travel to Los Angeles, San Francisco and intermediate points, this development constraint is altered. More land can be brought within reasonable distance of the central LA region because of the improved access, thus increasing the potential of the region to support additional job growth. Much of the available land in the Antelope Valley is not currently within commuting distance to LA with the congestion on SR14. Additionally, access to cities in the central valley and San Francisco is extremely limited.

Proposed improvements to SR14 are unlikely to significantly alter this picture. HSR thus allows the greater LA economy to fully leverage the land resources of the Antelope Valley, and, thus plays a strategic role in the LA economy. It can only do this with a station serving the areas with available land. The Antelope Valley alignment is one of the only available alternatives which is capable of this development.

4.1.3 Estimating the Development Impacts

Figure 0-1 presents the structure and logic of the methodology which is used to estimate long run economic impacts associated with a station location in Palmdale linking the Antelope valley to San Francisco and Los Angeles. The inputs in this model are described in turn below.

Several factors contribute to the estimation of these impacts. First, the maximum potential development impact is determined by estimating the number of households which could be accommodated within a reasonable access distance of the Palmdale station. This is further constrained by the total land area brought within reasonable distance/time of LA.[23] We then project the residential density under a full development scenario. We then subtract the current population of the commuter zone to get the potential impact in terms of the number of households.

This base number of households is further adjusted to reflect estimated HSR ridership to and from Palmdale. That is, an individual relocating to Palmdale who does not use the HSR services would not be included in the economic impact calculations associated with the rail line. We further reduce this figure to reflect the fact that some of the new riders/residents are not genuinely incremental to California, but represent a shift of population from other parts of California.

Having arrived at an estimate of the new households associated with the Antelope Valley HSR alignment, we multiply by the number of employees per household and average income by sector to obtain employment and income effects by industry sector. This represents the direct incremental income associated with the Antelope Valley high speed rail alignment. It is the

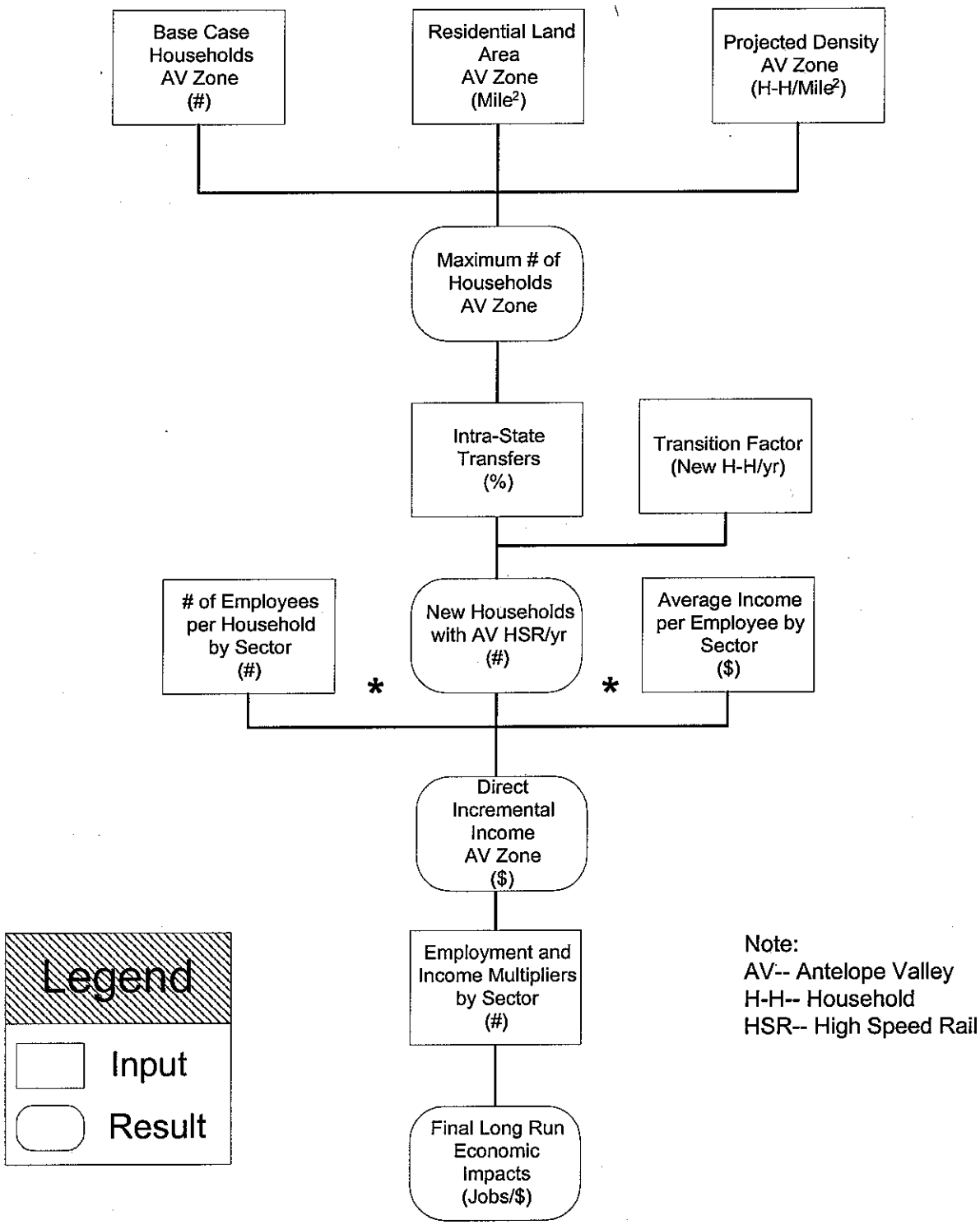
[23] Antelope Valley--LA riders are used as the constraining factor on potential household growth which is directly caused by the implementation of high speed rail. This is considered a conservative estimate, as riders to San Francisco and other points north may have also been influenced by the HSR system when making their residential location choices.

economic output generated by the employees who would not have been able to stay in the region had it not been for access granted by the high speed rail to the Antelope Valley.

The direct impacts of the high speed rail line are translated into total impacts using standard estimation techniques.[24] These techniques use economic multipliers to measure the indirect and induced effects of an initial investment in the form of earnings and employment.

[24] HLB developed a risk analysis based version of the input/output model and data provided in, US Department of Commerce, (1992), *Regional Multipliers: A User Handbook for the Regional Input-Output Modeling System (RIMS II). Bureau of Economic Analysis*, Washington DC

Figure 0-1 - Antelope Valley Economic Development Impact Model (Long Run Impacts)



Timing

Due to normal constraints in the development and residential growth process the new development will not happen immediately. This model reflects the gradual increase in development over a five year time period. This is also realistic in that the new employment made possible by the new residential development may take several years to come about as various sectors in the regional economy grow.

Risk Analysis

In order to reflect the uncertainty regarding the various factors that go into the above analysis, probability ranges have been developed for each factor. HLB's risk analysis model then estimates probability distributions for each of the inputs. These distributions are combined using sampling techniques to generate probabilistic results. These results provide an estimate of the expected value (mean) and the range of possible outcomes.

Model Inputs

Table 0-1 provides the key input assumptions and risk analysis ranges.

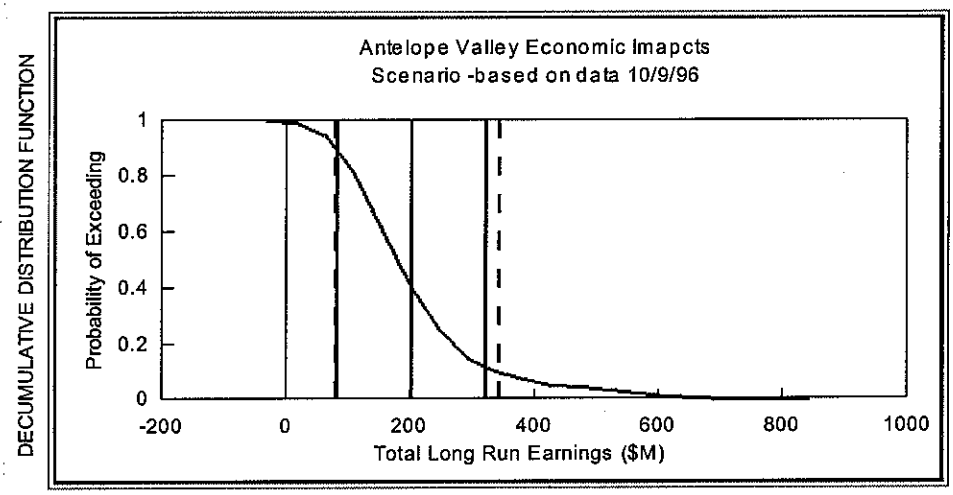
Table 0-1 - Long Run Development Impact -- Input Assumptions

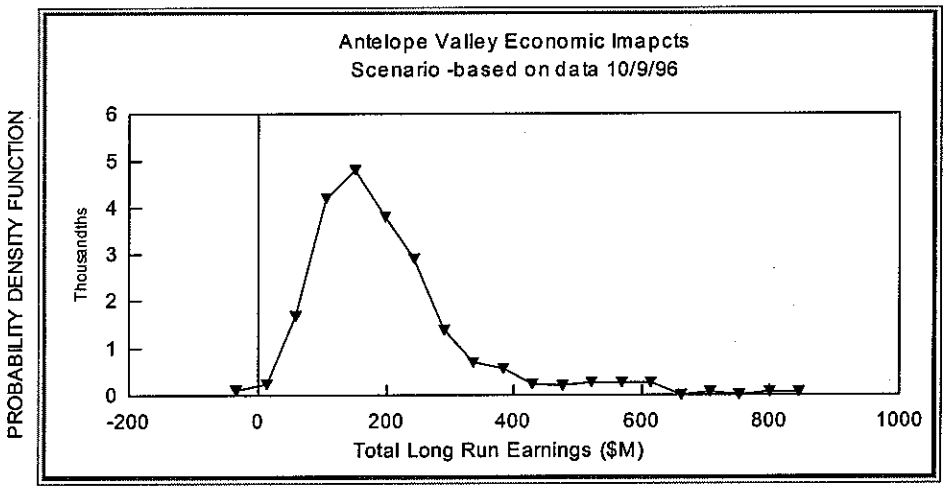
	Median	Lower 10%	Upper 10%
Projected density(HH/Sq. mile)	1,280	1,120	1,460
Land area impacted (Sq. miles)	95	80.75	109.25
Current area households('000)	69	66	72
Intra-State transfers (%)	97	94	97.6
Employment per household	1.22	1.10	1.34
Incremental new area households	1,907	864	3,270

4.1.4 Model Results

The long run total economic development impacts directly associated with the Palmdale station and the Antelope Valley alignment are estimated to have an expected value of $199 million and 4,300 jobs. The eighty percent confidence interval, which encapsulates both of the upper and lower 10% values, shows that the range of earnings is between $85 million to $340 million. And, the range of impact for employment, with an eighty percent confidence level is 1,900 to 7,200 of permanent jobs directly generated by the high speed rail investment. Figure 0-2 and Figure 0-3 present the complete set of risk analysis results for employment and earnings based on the above assumptions.

Figure 0-2 - Long Run Earnings Impact From A-V Alignment





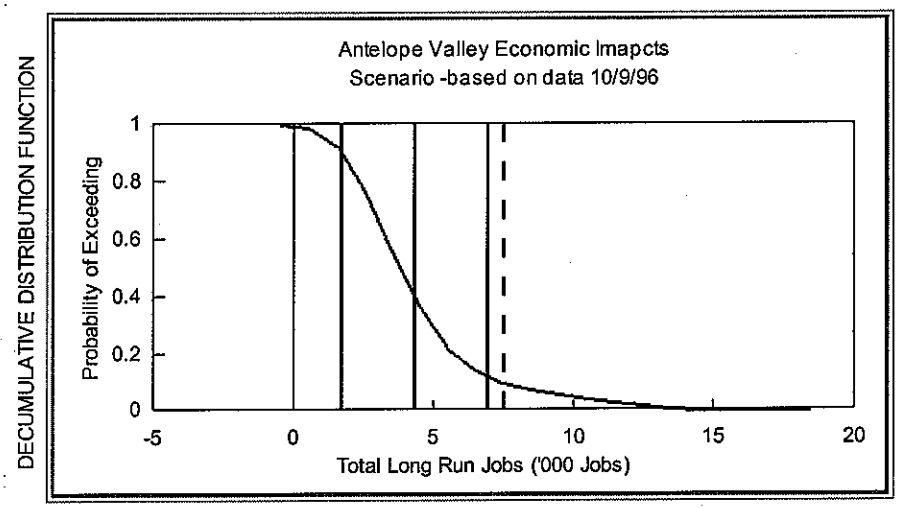
Antelope Valley Economic Imapcts

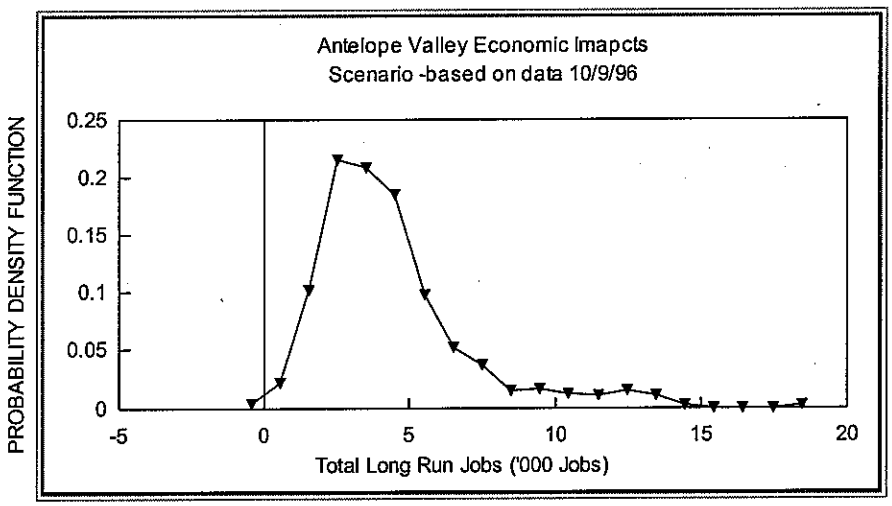
Scenario -based on data 10/9/96

TOTAL LONG RUN EARNINGS ($M)

Value	Probability of Exceeding Value to the Left
14.57	99%
56.55	95%
75.66	90%
108.33	80%
130.53	70%
152.76	60%
175.97	50%
199.44	40%
229.24	30%
267.29	20%
339.98	10%
454.82	5%
629.29	1%
Mean = 199.17	**Std. Dev.=121.24**

Figure 0-3 - Long Run Employment Impacts From A-V Alignment





Antelope Valley Economic Imapcts

Scenario -based on data 10/9/96

TOTAL LONG RUN JOBS ('000 JOBS)

Value	Probability of Exceeding Value to the Left
0.14	99%
1.09	95%
1.66	90%
2.29	80%
2.82	70%
3.29	60%
3.78	50%
4.29	40%
4.92	30%
5.73	20%
7.45	10%
10.05	5%
13.38	1%
Mean = 4.29	**Std. Dev.=2.61**

4.2

SHORT RUN ECONOMIC DEVELOPMENT IMPACTS

In addition to the long run permanent income and employment impacts described above, the construction of a high speed rail passenger terminal will generate direct, indirect and induced economic impacts. Figure 0-4 presents the structure and logic of the methodology used to estimate short run impacts. This is much more straightforward then identifying the long term dynamic effects of the Antelope Valley Alignment.

In this case, the initial capital investment is translated into final economic impacts using the appropriate multipliers and the multipliers are given for the state of California's Transportation Construction Industry. These multipliers are applied to the initial direct investment to generate indirect and induced effects and ultimately the total effect.

4.2.1 Input Assumptions

Table 0-2 presents the input assumptions for short run development impacts.

Table 0-2 - Short Run Development Impacts -- Input Assumptions

Input	Median	Lower 10%	Upper 10%
Project Capital Expenditures ($M)	$10.0	$8.0	$12.0
Length of Project (Years)	3	2.4	3.6
% of Expenditure Absorbed in the Local Economy	90	72	100

4.2.2 Results

The short run impacts from terminal construction are far less significant than the long run impacts, but, nonetheless, they will provide an immediate spark to the regional economy. From an estimated $10 million in expenditure the state economy is expected to benefit in the form of an expected 100 jobs and an additional $6.5 million in earnings. This translates into a final economic impact of approximately $22 million. Figure 0-5 and Figure 0-6 present the risk analysis results for employment and earnings. Figure 0-7 presents risk analysis results for the total short run impacts including direct, indirect and induced effects.

Figure 0-4 - Antelope Valley Economic Development Impact Model (Short Run Impacts)

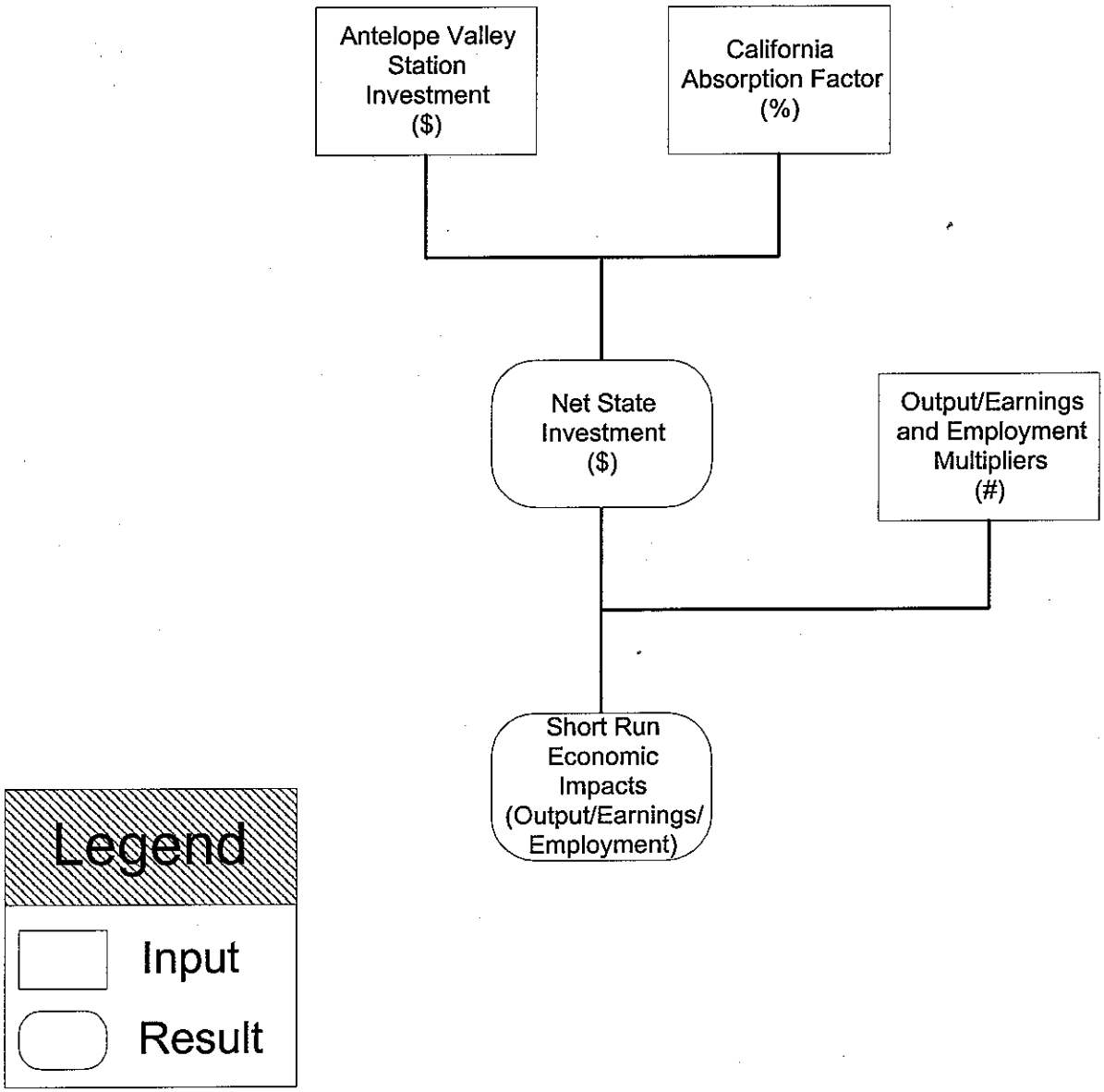
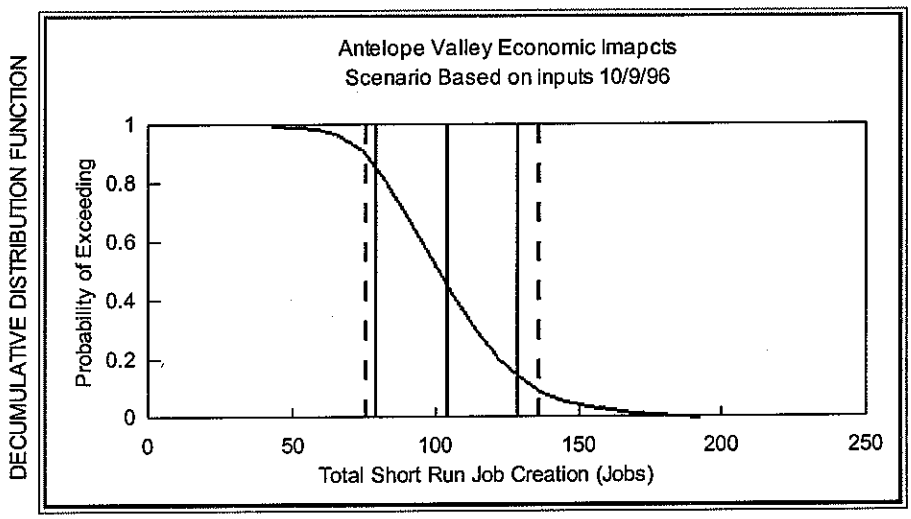
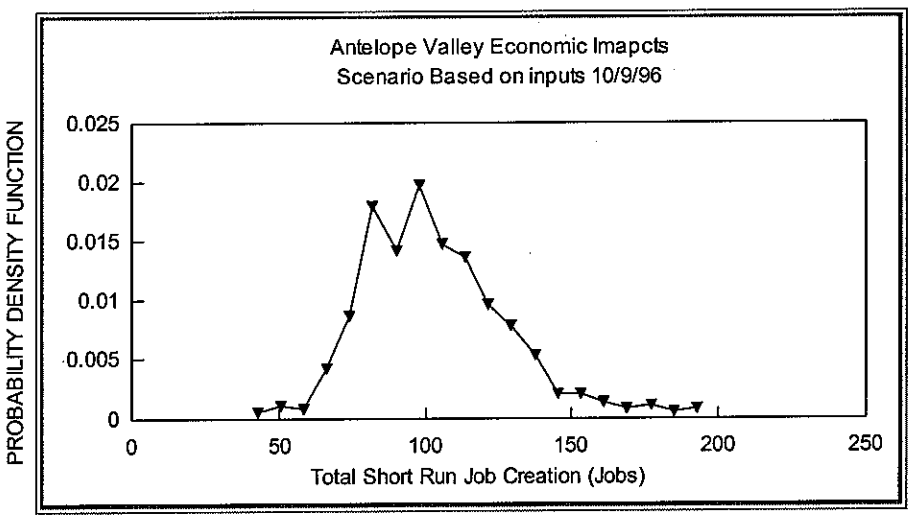


Figure 0-5 - Short Run Employment Impacts From A-V Alignment





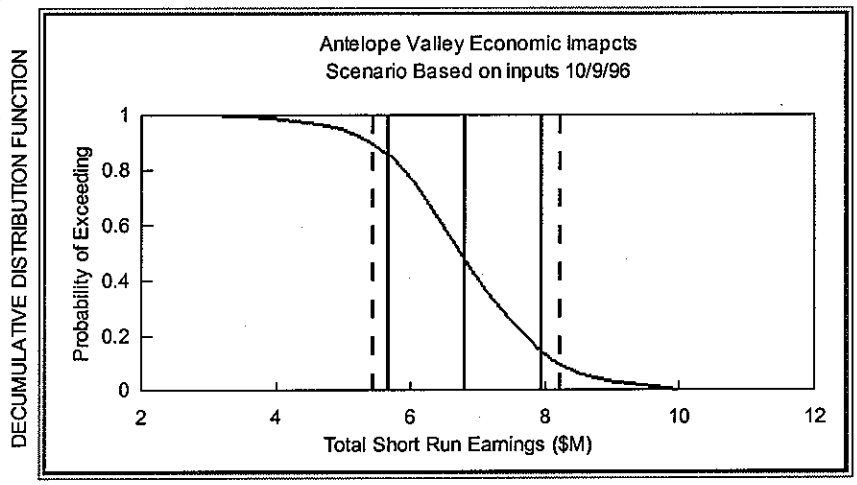
Antelope Valley Economic Imapcts

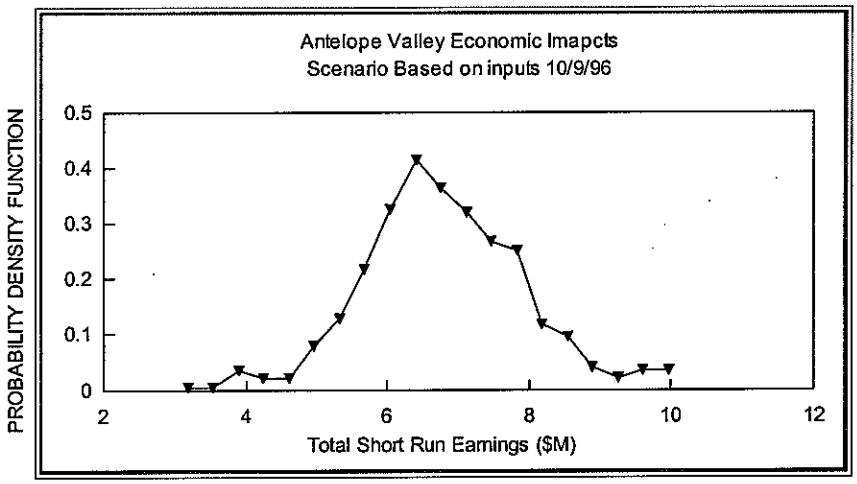
Scenario Based on inputs 10/9/96

TOTAL SHORT RUN JOB CREATION (JOBS)

Value	Probability of Exceeding Value to the Left
52.74	99%
68.59	95%
75.21	90%
82.61	80%
88.83	70%
94.77	60%
100.62	50%
106.57	40%
113.62	30%
122.42	20%
135.32	10%
149.13	5%
182.01	1%
Mean = 103.47	**Std. Dev.=24.79**

Figure 0-6: Short Run Earnings Impacts From A-V Alignment





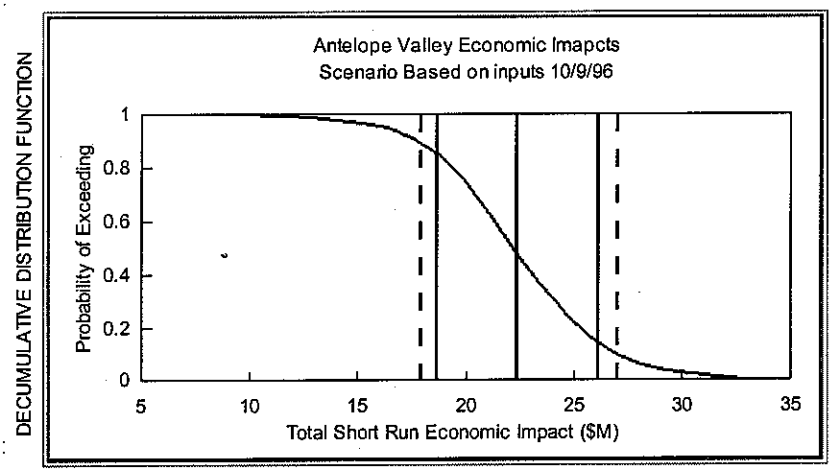
Antelope Valley Economic Imapcts

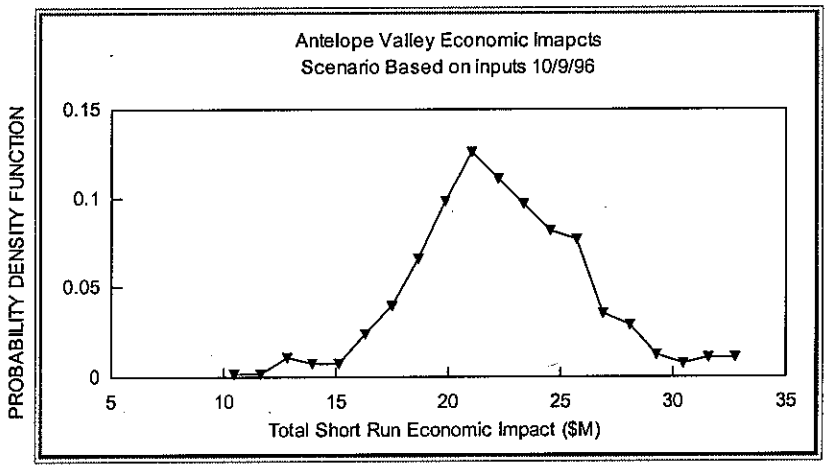
Scenario Based on inputs 10/9/96

TOTAL SHORT RUN EARNINGS ($M)

Value	Probability of Exceeding Value to the Left
3.89	99%
5.00	95%
5.42	90%
5.88	80%
6.19	70%
6.46	60%
6.72	50%
7.01	40%
7.33	30%
7.70	20%
8.19	10%
8.73	5%
9.85	1%
Mean = 6.78	**Std. Dev.=1.13**

Figure 0-7 - Total Short Run Impacts: Direct, Indirect, and Induced





Antelope Valley Economic Imapcts

Scenario Based on inputs 10/9/96

TOTAL SHORT RUN ECONOMIC IMPACT ($M)

Value	Probability of Exceeding Value to the Left
12.80	99%
16.45	95%
17.82	90%
19.34	80%
20.37	70%
21.24	60%
22.09	50%
23.04	40%
24.10	30%
25.31	20%
26.93	10%
28.71	5%
32.38	1%
Mean = 22.30	**Std. Dev.=3.72**

4.3 Long Run Antelope Valley Commercial Development Impacts

The above section deals with the potential for housing growth induced by HSR and the improved access it provides. It demonstrates the strategic role that HSR and the Antelope Valley can play in the statewide economy and, more specifically, in the economy of Greater Los Angeles. By improving access to affordable housing and a burgeoning community, the HSR link to the Antelope Valley improves the overall competitiveness of the state of California.

Antelope Valley's regional development strategy focuses on gaining self sufficiency through the development of new jobs and industries within the Antelope Valley. An Antelope Valley High speed rail service will undoubtedly contribute to this growth. It will provide timely travel to larger business centers while at the same time providing affordable commercial land and access to a diverse labor force. The following sections discuss several aspects of this potential growth and how it would be impacted by the Antelope Valley alignment.

4.3.1 Access to Commercial Space

While most commercial space in the Antelope Valley area has been retail, growth in office space has been rapid since the mid-1980's. Most of this has involved the growth of businesses providing services to the Antelope Valley market. In order to reach its full potential and move toward economic self-sufficiency, the Antelope Valley must continue to attract commercial employers with a regional and/or national outlook (See Exhibit R). For employers of this type, and their employees, accessibility is an important factor in location decisions.

4.3.2 Commercial Location and Transportation

Commercial business location is influenced by such factors as office rents, labor force availability, taxes and utilities, and the general business climate. However, accessibility is also a key factor, varying in significance by industry sector and type of transportation facility. Regional businesses require access to regional customers including short haul intercity access. Nationally oriented businesses require access to metropolitan centers and smaller businesses often require access to supporting business and financial services. Location of branches and back office operations of larger firms is often constrained by access to regional or national headquarters.

For these reasons commercial growth is often spurred, in part, by transportation improvements. This is usually linked to the development of airports which directly tie a regional economy to several other major metropolitan areas and improve access to the national airline grid. An HSR system with similar performance characteristics to airline service could be expected to have similar effects in that it links communities to major international airports and out-of state and international markets. Since Palmdale is a part of the greater Los Angeles economy, access to key LA centers such as downtown and Burbank will continue to be important to Antelope Valley's future. In addition, the Bay Area's weight in the region is sufficient to make access to it important to firms considering locating in the Antelope Valley.

4.3.3 Commercial Development Estimates

It is factors such as these that lie behind projected economic development estimates for the city of Palmdale. The Commission reports reasonably assume that most new commercial development associated with the station will take place within 1/2 mile of the new station. This is consistent with studies elsewhere in the country of the impact of rail access on commercial development. The estimated new development figure of $409 million seems reasonable given the recent and expected growth path of the Antelope Valley economy.

As the above discussion of business location decisions implies, it is not straightforward to estimate the portion of new commercial development which can be considered as incremental to a new rail station. The Commission's working paper appropriately stated this proportion as a range resulting in estimated development attributable to HSR of between $164 million to $184 million.[25] This development estimate places the Palmdale station fifth in terms of potential development out of twenty four potential stations.

4.3.4 Incremental Benefit to California

One of the most difficult issues in estimating the "true" benefit of economic development spurred by a transportation investment is estimating the amount of new growth as opposed to the shifting of economic activity within the state. Clearly, transportation plays an especially big role in locational decisions within a metropolitan area. A shift in employment to a rail station from other areas in California is not a net benefit to California. However, there is reason to believe that a particularly large portion of new commercial development at a Palmdale/Antelope Valley station would be a net benefit to California.

The above discussion of housing and population impacts highlighted the availability of affordable housing within commuting distance of central LA as a key constraining factor on employment growth in the region. One possible way for the region to overcome this constraint is by the movement of employment from central LA to peripheral locations within the metro area, freeing up central LA for those jobs which can only be located there. Antelope Valley is ideally suited for this role. However, many of the jobs which might shift would still require excellent access to central LA. One thinks especially of bank operation centers and similar back office operations which require close ties to front office operations.

The optimal location for such facilities is close to a large labor pool with inexpensive housing with close transportation access to headquarters facilities. In the absence of such an area in greater LA, logical locations for such facilities are probably Tucson and Phoenix. With high speed rail access Antelope Valley becomes the most logical site for such operations. While it difficult to precisely quantify these effects, we have estimated a reasonable probability range for economic activity which is considered incremental so that it can be appropriately added to the housing impacts described in the above section.

[25] Economic Research Associates High Speed Rail Working Paper 11 Summary.

4.3.5 Industrial and Aerospace Impacts

Another key economic development goal for the Antelope Valley is to expand light manufacturing, especially the aerospace industry. To the extent that HSR can support this effort, it will add additional economic benefits.

Typically manufacturing location decisions are much less directly impacted by passenger transportation facilities than are commercial location decisions. Costs of labor, utilities, industrial land and freight transportation access are more significant. There is reason to believe that passenger transportation access may be more important for the kinds of industry Antelope Valley is trying to attract than for other manufacturers. Aerospace, and especially the civilian aerospace sector being pursued, is a rapidly changing, R&D intensive sector. Access to universities, customers, suppliers, and government officials is likely to be of key importance. This is one reason this remains a key industry for Southern California. By improving access, both to the rest of Southern California and to the high technology and research centers of the Bay Area, Antelope Valley's competitiveness as well as the state of California's could be improved (See Exhibit K).

Offsetting this to some degree is the likelihood that the direct impact of high speed rail will be concentrated in the area with closest proximity to the rail station itself. Manufacturing facilities in Antelope Valley, as elsewhere, tend to be located in areas where land is relatively inexpensive and there is suitable zoning They are less likely to concentrate in a small zone than are other commercial users. This is another reason why the impact on manufacturing of HSR is likely to be less than the impact on commercial development.

4.3.6 Interaction of Residential, Commercial and Industrial Effects

There is likely to be at least some positive synergy between the different forms of development spurred by HSR. Amenities and support services generated by residential growth may improve the area's attractiveness for commercial growth. The residential growth forecasts supporting the housing-based development impacts occur within a relatively tight circle around the Palmdale station, leaving other parts of the Antelope Valley unaffected.

4.3.7 Potential Palmdale Airport Expansion

There are pending plans to expand the Palmdale airport, either to accommodate out-of-state passenger flights or to make it a cargo center. The former especially would be made more viable by the presence of an HSR station (Exhibit M).

4.3.8 Induced Demand, Economic Development and HSR Ridership

In addition to providing direct and indirect economic benefits, these changes in development patterns may have a significant impact on ridership projections. The HSR ridership estimates did not consider projections for economic and demographic growth outside of a normal growth pattern. The ridership forecast does reflect new trips expected to be induced by the availability of high speed rail but not for ridership tied directly to large scale new economic growth close to rail stations. In this sense, induced demand estimates were conservative (see Exhibit G).

It is likely that the incremental ridership associated with the Palmdale station is significantly underestimated due to the failure to reflect these development impacts. $400 million of new development within 1/2 mile of the Palmdale station is certain to lead to greater ridership (Exhibit M). Even if some of this represents shifts of development from elsewhere in Southern California it represents a source of increased ridership due to the role of access/egress time and costs in determining mode shares for high speed rail (see Exhibit M).

4.4 Conclusions

The above analyses point to both the nature of potential economic development impacts for the Antelope Valley and the area adjacent to the Palmdale station. As Commission reports indicate, the Antelope Valley is going to be one of the major sources of economic development activity if a Palmdale station is part of the California high speed rail alignment (Exhibit O).

Table 0-3 summarizes the results of the economic development analysis in the Antelope Valley region resulting from high speed rail. The table indicates that, even with a notional estimate of manufacturing impact, the expected economic development impact in the region exceeds $318 million, with an eighty percent confidence interval of $190-$479 million.

Table 0-3: Summary of Economic Development Impacts

Economic Development Component	Median	Lower 10%[a]	Upper 10%[a]
Long Run Development Impact - Residential Growth due to Access (millions)[b]	$199	$85	$340
Commercial Development Impact (millions)[c]	$87	$82	$92
Manufacturing Impact (millions)[d]	$10	$5	$20
Short Term Impact Station Investment ($ millions)[b]	$22	$18	$27
Total	$318	$190	$479

a - These are values represent probability ranges and are not strictly additive.
b - HLB estimates.
c - HLB estimates based on ERA study. Assumes 50% of ERA estimate absorbed in the state economy.
d - Notional values.

The economic development benefits are far reaching and benefit the residents of the Antelope Valley. But just as important is the degree to which the Antelope Valley alignment generates economic activity for the state of California, thereby improving the viability of the entire system.

5. CONCLUSIONS

This report shows that the Antelope Valley high speed rail alignment is the route which is most likely to maximize the net benefits of high speed rail for California. Ridership estimates and capital costs for the two potential alignments are not significantly different from each other. In fact, given the uncertainties associated with the ridership forecasts, there is no basis for considering the Grapevine Pass alignment as having a higher expected ridership. There is also a possibility that the capital costs for the Antelope Valley alignment will be the same or even lower than for the Grapevine alignment. Therefore, even from a pure transportation benefits point of view, the Antelope Valley alignment will likely prove to be the superior alignment alternative.

However, the transportation benefits are only part of the picture. The potential for high speed rail to foster economic development benefits in the Antelope Valley are considerable, even in the most conservative case. The most conservative estimate shows an economic development benefit to the state of $190 million. This impact is more likely to be in excess of $400 million which far surpasses any expected difference in capital costs associated with the two alignments (see Exhibit N).

5.1 Results of Current Analysis

The current analysis in the Commission Summary Report is based on projected differences in ridership and capital cost figures. The ridership study estimates that the Grapevine Pass alignment will generate 900,000 more riders than the Antelope Valley alignment. Capital costs are estimated at $540 million less for the Grapevine Pass alignment than for the Antelope Valley alignment.

There was no full analysis of transportation benefits or economic benefits for the two alignments. As was discussed in section 1, such an analysis may not be necessary if all benefits vary directly with ridership and incremental ridership and capital cost differences are certain. Instead, net transportation benefits are assumed to be less for the Antelope Valley alternative.

As was discussed in sections 2 and 3, ridership and capital cost are uncertain. Additionally, the current analysis reflects no estimate for incremental economic development impacts resulting from the Antelope Valley alignment or potential commuter rail benefits. The judgment based on the sum of these considerations was to prefer the Grapevine Pass alignment. Table 0-1 summarizes the results of this analysis.

Table 0-1: Summary of Current Analysis of Antelope Valley High Speed Rail Alignment

Indicator	Current Analysis Antelope Valley Compared to Grapevine Pass
Ridership Difference (Passengers-2015)	-900,000
Capital Cost (Million)	$540
Net Transportation Benefits of HSR	Expected Benefits are Less for A-V from Preliminary Analysis
Economic Development Impacts from HSR	NC
Net Transportation Benefits of HSR with Integrated Commuter Rail	NC
Total Net Benefit	**NC**

NC-- Not considered.

5.2 Risk Analysis Results

The risk analysis results in the report, together with the economic development impacts, provide for a different set of conclusions. The risk analysis results for ridership and capital costs show that the Grapevine Pass alignment is likely to be the higher risk alternative. Therefore, from a pure transportation benefits perspective, the Antelope Valley alignment may generate a more desirable outcome in terms of the risk-yield tradeoff which is part of all major infrastructure decisions. Table 0-2 summarizes the risk analysis results.

When all of the potential impacts of high speed rail are considered, there is no doubt that linking the Antelope Valley to the high speed rail system in California improves the overall viability of the system. Failing to link the fastest growing communities in California to Los Angeles and San Francisco represents a significant loss in opportunity for the state economy and for high speed rail.

Table 0-2: Risk Analysis of Alternative High Speed Rail Alignments through the Central Valley

Indicator	Antelope Valley Compared to Grapevine Pass Risk Analysis Results
Ridership Difference in 2015	80% Probability Range -400,000 to +700,000
Capital Cost (Million)	80% Probability Range -$70 to +$882
Net Transportation Benefits of HSR	No Statistical Difference
Economic Development Impacts of HSR (Million)	80% Probability Range +$180 to +$479
Net Transportation Benefits of HSR with Integrated Commuter Rail (Million)	80% Probability Range +$5 to +$10
Total Net Benefit	**Strong Probability of Greater Total Net Benefits**

Source: HLB estimates based on HLB risk analysis and California Intercity High-Speed Rail Commission, (1996), *Summary Report and 20 Year Action Plan.*
NC-- Not considered.

EXHIBIT A: POPULATION & EMPLOYMENT GROWTH

EXHIBIT B: SR-99: GRAPEVINE CORRIDOR

EXHIBIT C: COST BENEFIT ANALYSIS OF SR 99 SHORT CORRIDOR

EXHIBIT D: RIDERSHIP AND REVENUES FORECASTS

EXHIBIT E: HIGH SPEED RAIL ALIGNMENTS

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EXHIBIT K: SCAG REGION 1998 RTP FOR 2020

EXHIBIT L: HOUSING COST IN SOUTHERN CALIFORNIA

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EXHIBIT N: CAPITAL COST OF ALTERNATIVE ALIGNMENTS

EXHIBIT O: INTERCITY HIGH-SPEED RAIL COMMISSION RECOMMENDATIONS

EXHIBIT P: OPERATING COST FOR ALTERNATIVE ALIGNMENTS

EXHIBIT Q: SHORT HAUL INTERCITY TRIPS

City of Palmdale

Economic Risk Analysis of Construction Costs, Schedule, and Benefits associated with High-Speed Rail Alignments between Los Angeles and Bakersfield

Final Report

March 5, 2003

CITY OF PALMDALE

ECONOMIC RISK ANALYSIS OF CONSTRUCTION COSTS AND SCHEDULE ASSOCIATED WITH HIGH-SPEED RAIL ALIGNMENTS BETWEEN LOS ANGELES AND BAKERSFIELD

FINAL REPORT

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March 5, 2003

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EXECUTIVE SUMMARY

The purpose of this report is to evaluate and compare the costs of two possible rail alignments along the Bakersfield – Sylmar section of the California High Speed Rail (HSR) project. Both alignments go through a mountainous terrain (the Tehachapi Mountains), necessitating significant excavation and tunneling work.

The analysis was conducted within a comprehensive economic risk analysis framework, which recognizes and accounts for four categories of risk:

- Tunneling geological risks;
- Cost escalation risks;
- Schedule slippage and financial costs; and
- Methodological uncertainty.

The geological risk factors used in this paper were derived from assumptions and simulation results provided by Geodata, an engineering company with particular expertise in the design of underground structures in complex and difficult ground conditions.

The four risk factors, along with engineering unit cost estimates found in the literature, were expressed as probability distributions. Monte Carlo simulation techniques were then used to combine these distributions and derive probability distribution for segment construction costs and total project costs. Simulated construction costs for the Bakersfield – Sylmar segment are summarized in the table, below.

Table ES-1: Simulation Results for Tehachapi Mountain Crossing Construction Costs

In Millions of 2003 Dollars	Mean Expected Outcome	80% Confidence Interval	
		Lower Bound	Upper Bound
With 3.5% Maximum Grades			
Antelope Valley	$2,342	$2,106	$2,597
I-5	$2,594	$2,315	$2,887
Difference	*-$252*	*-$209*	*-$289*
With 2.5% Maximum Grades			
Antelope Valley	$3,001	$2,724	$3,287
I-5	$2,969	$2,621	$3,331
Difference	*$31*	*$102*	*-$44*

As shown Table ES-1, with 3.5% maximum grades, the extra costs and risks associated with tunnel construction along the I-5 alignment more than offset the extra miles of construction necessary along the longer Antelope Valley Alignment. At any probability level, the I-5 construction costs are *larger* than the Antelope Valley costs.

With 2.5% maximum grades, total construction cost along the Antelope Valley alignment is only marginally larger than along the I-5 alignment ($31million at the median). The table also shows that the range of possible costs for I-5 is larger than for the Antelope Valley, reflecting the considerable uncertainty associated with I-5 ground conditions, highlighted by Geodata in their assessment of geological risks.

Simulated grand total project costs[1] are shown in the table below. Overall, the Antelope Valley alternative appears less costly than the I-5 alignment when controlling for potential construction delays, geological risks, cost escalation and differences in financial costs.

Table ES-2: Simulation Results for Grand Total Project Costs

In Millions of 2003 Dollars	Mean Expected Outcome	80% Confidence Interval	
		Lower Bound	Upper Bound
With 3.5% Maximum Grades			
Antelope Valley	$26,830	$24,116	$29,598
I-5	$27,808	$24,691	$31,210
Difference	*-$977*	*-$575*	*-$1,612*
With 2.5% Maximum Grades			
Antelope Valley	$27,610	$24,945	$30,393
I-5	$27,966	$25,086	$31,153
Difference	*-$356*	*-$141*	*-$760*

Decumulative probability distributions for total project costs are shown in Figures ES-1 (for 3.5% maximum grades) and Figure ES-2 (for 2.5% maximum grades), below. Note that the delay risk reflected in the additional financial cost offset the cost differential between the alignments due to the longer length of the Antelope Valley alignment.

[1] For Phase 1 (San Jose - Fresno to Los Angeles) and Phase 2 (adding connections to Sacramento – Modesto in the North, and San Diego in the South)

Figure ES-1: Simulated Total Project Costs, 3.5% Maximum Grades

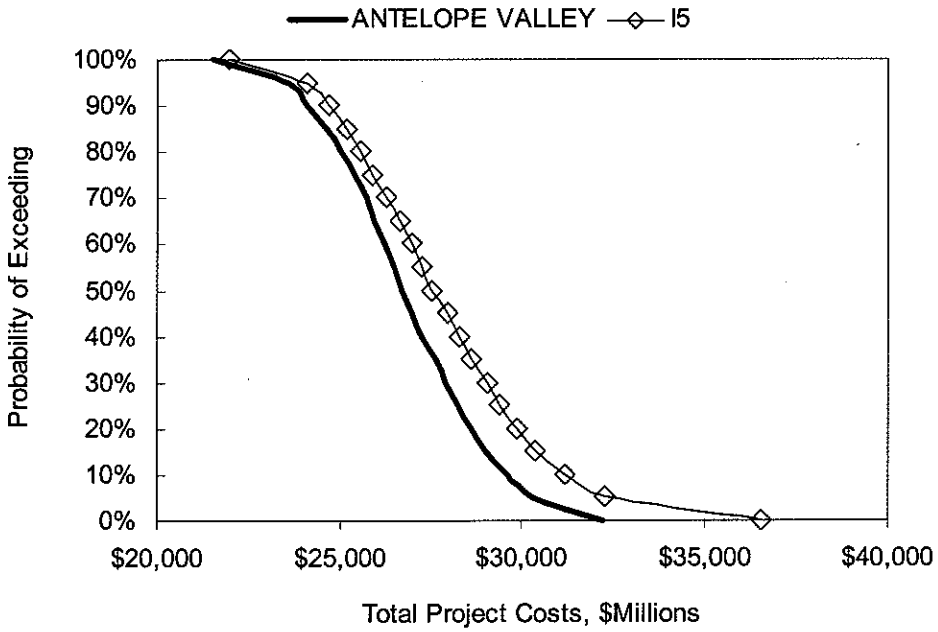
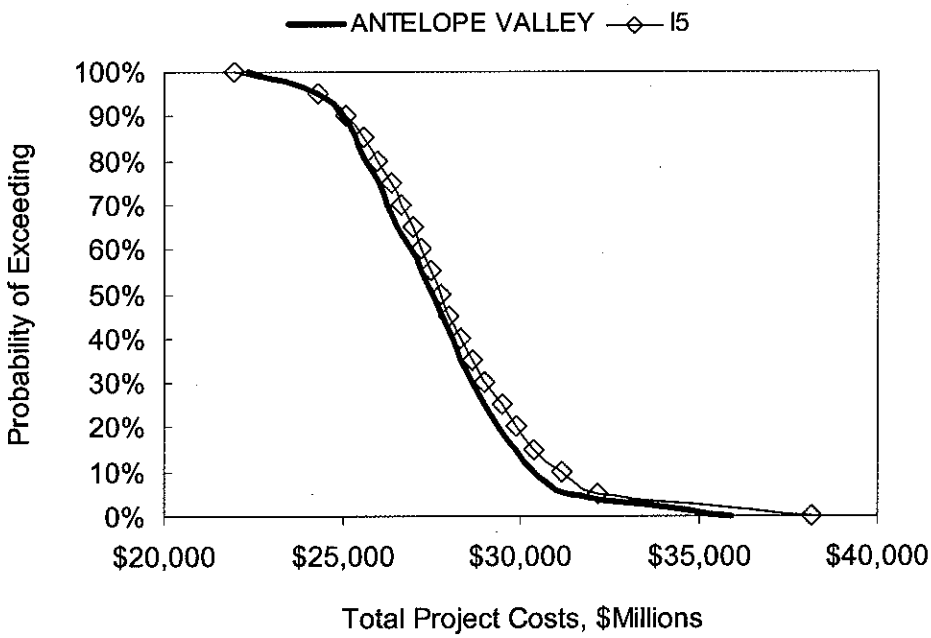


Figure ES-2: Simulated Total Project Costs, 2.5% Maximum Grades



In a previous study conducted in 2001, HLB established that the Antelope Valley option would generate significantly more economic opportunities and benefits than the I-5 alignment:

- The Antelope Valley option would result in higher cumulative ridership and revenue. It would result in a 10 to 12 minute longer travel time (or 7% of total travel time) between Los Angeles and San Francisco, but would also provide access to over 700,000 higher life-cycle population and related high-tech employment.

- The Antelope Valley option would provide greater intermodal connectivity (through the Palmdale Regional Airport), greater access to and support of key industrial resources, and over $540 million in aggregate net new economic stimulus over the project life-cycle.

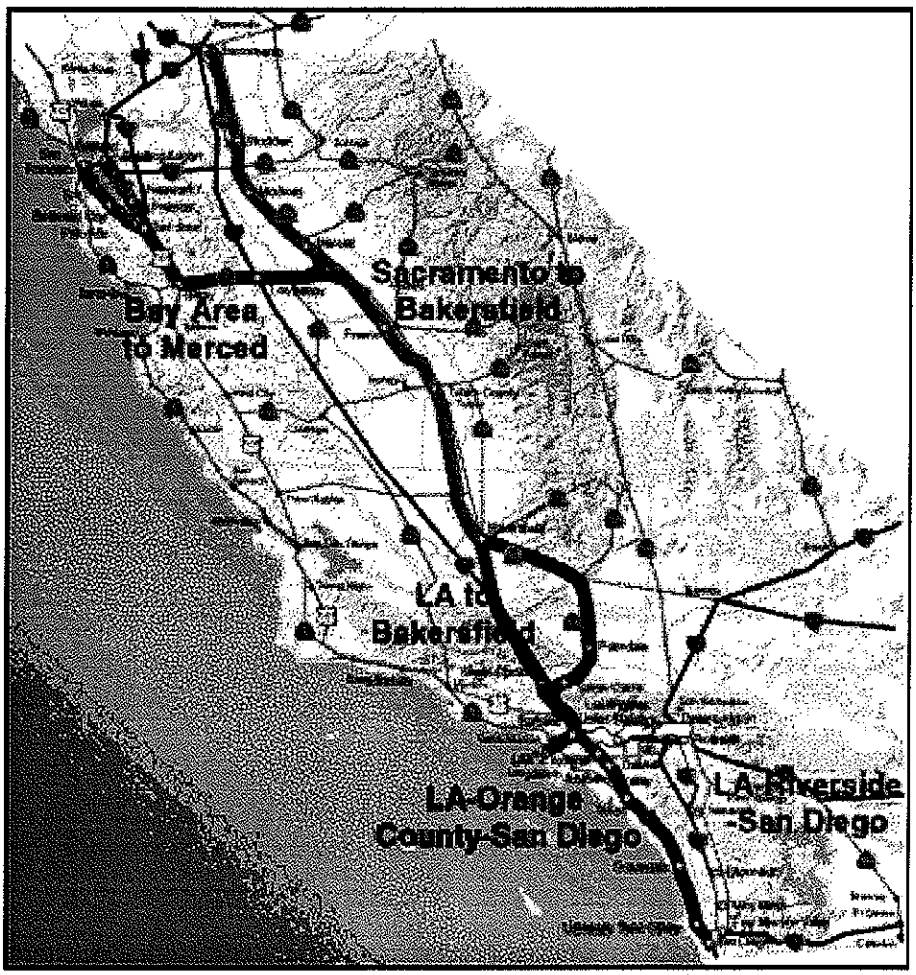
- The Antelope Valley option offers the best chance for maximizing net project benefits. It would generate $23.5 billion in economic benefit *over and above* capital and operating expenses, or *$0.9 billion more* than the I-5 Alignment.

Thus from a total economic cost benefit perspective, the Antelope Valley alternative is the risk minimizing option, when considering both general ridership and revenue risks, and the risks pertaining to construction costs and project schedule.

1. INTRODUCTION

This paper provides an economic risk analysis associated with the design and construction of the high speed train project between Bakersfield and Sylmar, along the Tehachapi Mountain Crossing, just North of Los Angeles. A map of the California high speed rail project is provided as Figure 1, below.

Figure 1: The California HSR Alignment



Source: "Alignment Refinement/Optimization and Evaluation of the Quantm System," Figure 1-1, page 11

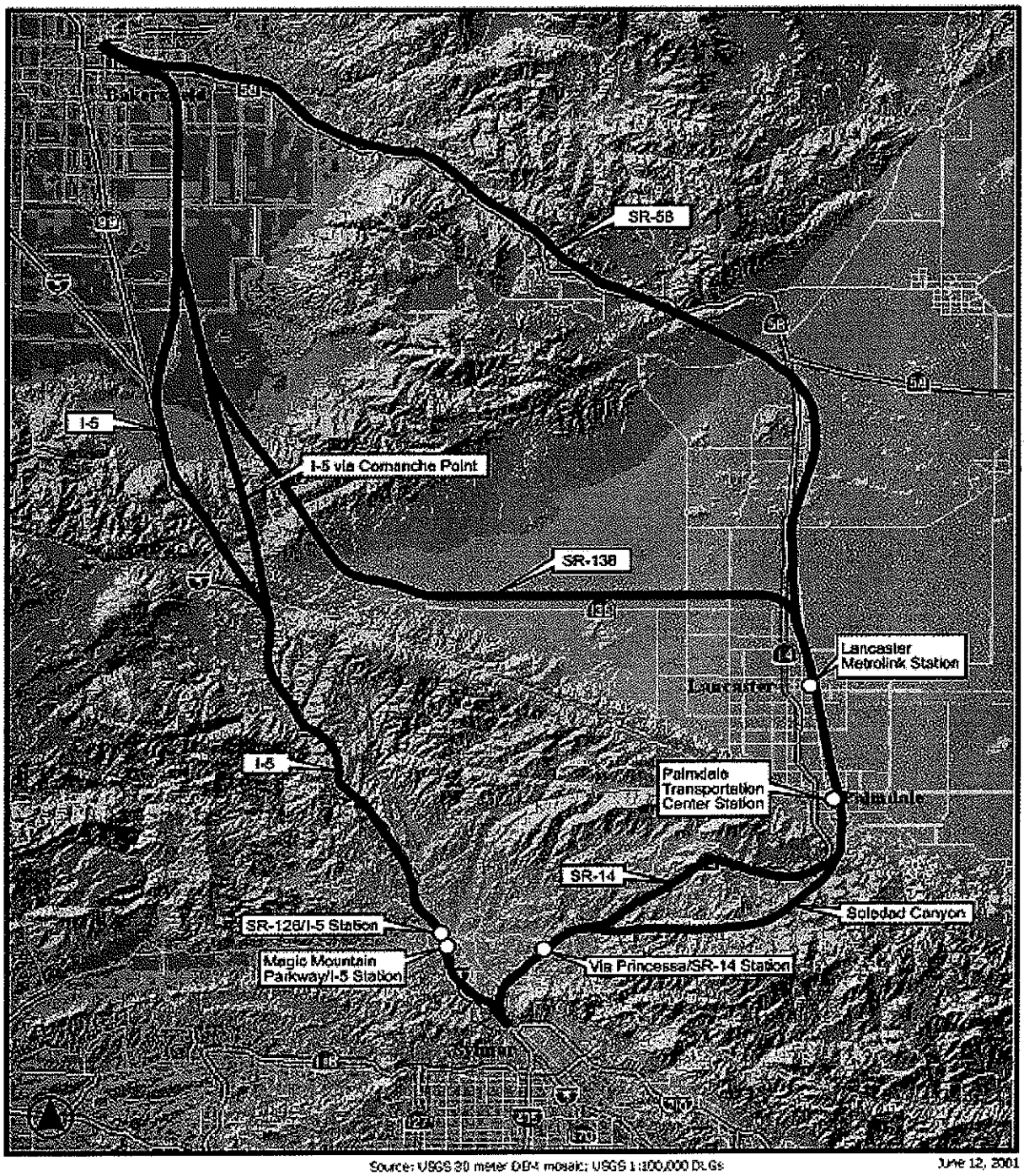
Two options are considered in this study:

1) The Antelope Valley Alignment (from Sylmar to Palmdale via Soledad Canyon; Palmdale to Mojave, and Mojave to Bakersfield via SR58); and

2) The I-5 Alignment (from Sylmar to Bakersfield, following Interstate 5).

Both alignments are evaluated under a 2.5% and 3.5% maximum grade scenario. They are shown in Figure 2, below, reproduced from Parsons Brinckerhoff April 2002 engineering report.

Figure 2: Tehachapi Mountain Crossing



Source: "Alignment Refinement/Optimization and Evaluation of the Quantm System," Figure 3-1, page 22

The rest of the paper is structured as follows. After this introduction, Chapter 2 provides a brief review of the technical literature on high speed rail cost components and cost estimates. Chapter 3 identifies key risk factors to consider in the evaluation of high speed rail alignments, including geological and economic risks. The chapter utilizes findings developed by Geodata, a geo-engineering company with particular expertise in the design of underground structures in complex and difficult ground conditions.

Simulation results for the Tehachapi Mountain Crossing segment are presented in Chapter 4, while Chapter 5 examines the effects of potential cost and schedule slippages along the Tehachapi segment on the overall project capital costs. Chapter 6 concludes with a summary of findings and a brief discussion on expected economic benefits under the two options analyzed in the study. Various appendices are provided at the end of the report.

2. OVERVIEW OF THE TECHNICAL LITERATURE

This chapter provides an overview of the existing literature on HSR cost categories and estimates. The review is in no way exhaustive but merely serves as an illustration for the type and range of existing cost estimates. Overall, it is found that estimates from other countries or corridors within the Nation are only of *limited* interest given the importance of local conditions and project characteristics in determining HSR unit costs (cost per mile) and total costs.

2.1 Cost Categories and Estimates

High speed rail capital expenditures typically include:

- Land and right-of-way preparation
- Utility relocation
- Track construction (new and upgrade of existing) and realignment
- Grade crossing protection, separation, closure, and fencing
- Electrification and signaling
- Guideway construction
- Bridges and tunnels (new or rehabilitated)
- Terminal and station construction or upgrades
- Maintenance-of-way facilities
- Maintenance-of-equipment facilities
- Central control, administration and reservations system
- Other equipment, including spares

The share of various cost components for the California HSR projects was estimated as follows:

Table 1: California HSR Cost Components

Cost Categories	Percentage of Total
Station Costs	4%
Track and Guideway Systems	4%
Earthwork and Related Items	4%
Structures	18%
Grade Separations	6%
Right of Way	5%
Environmental Mitigation	2%
Rail & Utility Relocations	1%
Signals and Communications	2%
Electrification Items	5%
Subtotal	**58%**
Program Implementation	17%
Contingency	14%
Vehicles	6%

Support Facilities	2%
Total Costs	**100%**

Source: Parsons Brinckerhoff, 1996; See Appendix 1 for details

In the 1994 study, "Potential for Improved Intercity Passenger Rail Service in California," by Leavitt D, Hall P, Vaca E, and Hall, six cost components were considered: earthworks, structures, buildings, rail, power and signals, and right-of-way. Project costs were estimated as follows.

Table 2: Los Angeles - San Francisco High-Speed Line Infrastructure Costs

Segment	Total Costs ($Million)	Length (Miles)	Cost per Mile ($Million)
Los Angeles Basin	$901	24.2	$37.2
Tehachapi Mountains (via Palmdale)	**$3,350**	**85.0**	**$39.4**
Central Valley	$2,440	202.6	$12.0
Pacheco Pass - Gilroy	$1,930	33.6	$57.5
Gilroy - San Jose	$645	28.6	$22.5
San Jose – San Francisco	$2,384	48.4	$49.2
Total	**$11,650**	**422.3**	**$27.6**

Source: Leavitt D, Hall P, Vaca E, and Hall P (1994)
In dollars of 2003 (escalated with U.S. consumer price inflation)

Construction costs along the Tehachapi Mountain crossing were re-estimated recently. These estimates are shown in Table 3, below.

Table 3: Tehachapi Mountain Crossing Construction Costs

Segment	Total Costs ($Million)	Length (Miles)	Cost per Mile ($Million)
I5 / Grapevine Alignment	$4,480	55.2	$81.2
SR-58 / Mojave Alignment (via Palmdale)			
Southern Section	$2,170	33.4	$65.0
Northern Section	$3,270	46.1	$70.9

Source: "Alignment Refinement/Optimization and Evaluation of the Quantm System," 2002, before Quantm refinement.

Published cost-estimates for high-speed transit systems range from a relatively inexpensive $10 million per mile to systems costing $100 million per mile, or more. Examples of cost estimates for current high-speed projects are shown in Table 4, below.

Table 4: Sample High-Speed Project Costs

Project	Total Costs	Length (Miles)	Cost per Mile	Source
Pittsburgh Civic Arena	$147 M	0.41	$359 M	Pittsburgh Post-Gazette (March 7, 1999)
Pittsburgh Oakland Extension	$550 M	10	$55 M	Pittsburgh Post-Gazette (March 7, 1999)
Tokyo-Osaka	$20.8-$72 B	478	$43.5-$150 M	Charles Arthur Independent (June 1, 1998)
Hamburg-Berlin	$5.9 B	181	$33 M	Time Magazine (November 9, 1998)

Several factors affect high-speed project costs, including:

- Local conditions: land availability and acquisition, need for special structures such as bridges and tunnels, relocation of utilities, etc.
- The local economy: cost of locally manufactured inputs, such as pre-cast concrete components. If the system is to be located in a country with large supplies of sand and gravel, numerous pre-cast plants, and cheap labor, then the system will cost much less than one in an area that does not have these resources.
- Differences in technologies: conventional rail vs. Maglev technology, for example.

Again, according to North Carolina Transportation, *there is no simple way to estimate the costs of a high-speed transit project.*

Cost estimates for the French high speed train (the TGV) are shown below.

Table 5: French TGV Infrastructure Costs

Segment	Costs ($Million)	Length (Miles)	Cost per Mile ($Million)
South-East	$2,498	626.3	$4.0
Atlantic	$2,093	452.9	$4.6
Mediterranean	$4,913	499.1	$9.8
East	$5,306	673.7	$7.9
Total	**$14,810**	**2,252.0**	**$6.6**

Source: Société Nationale des Chemins de Fer, SNCF
In dollars of 2003 (escalated with U.S. consumer price inflation)

2.2 Implications for this Study

There is considerable variation and uncertainty in cost estimates found in the technical literature. Therefore, one should rely as much as possible on project-specific estimates when evaluating, and comparing, the costs of two or more possible alignments.

Finally, as an illustration of the degree of uncertainty surrounding HSR capital cost estimates, the Federal Rail Administration (FRA) recommends using *relatively* large percentage markups of project cost to allow for contingencies, design, and construction management, especially so for new construction projects (as opposed to upgrading of existing railways). This is illustrated in Table 6, below.

Table 6: FRA Cost Markups for High Speed Rail Projects

	Upgrading of Existing Railroads	New Construction
Contingencies	20%	25%
Design/Construction Management	10%	16%
Total Allowance	**30%**	**41%**

Source: FRA, Railroad Development High Speed Ground Transportation for America, http://www.fra.dot.gov/rdv/hsgt/cfs/chapter5.htm